

AMENDMENTS TO THE DRAWINGS

The attached Replacement Sheet 2 contains amendments to Figure 2. This Replacement Sheet 2 replaces the original sheet containing Figure 2. In Figure 2, reference elements 134 and 164 have been respectively replaced with reference elements 164 and 134, reference element 170 has been removed, and previously omitted reference element 132 has been added.

Attachment: Replacement Sheet
Annotated Sheet Showing Changes

REMARKS

This is intended as a full and complete response to the Office Action dated October 10, 2006, having a shortened statutory period for response set to expire on January 10, 2007. Please reconsider the claims pending in the application for reasons discussed below.

The drawings stand objected to by the Examiner for failing to comply with 37 C.F.R. § 1.84(p)(5). The Examiner asserts that the drawings do not include "chamber lid 132" as described in paragraph [0044] of the specification.

The Applicant amended Figure 2, on the Replacement Sheet 2, to have the chamber lid labeled with reference element 132.

Withdrawal of the objection is respectfully requested by the Applicant.

The specification stands objected to by the Examiner for having reference element 46A in Figure 1, and reference elements 152A, 152B, 162, 170, and 172, in Figure 2, but not defined in the specification. The Applicant has amended paragraphs 32, 34, 37, 44-48, 50, 54, 57, 61-62, 67, 82, 99, and 103 within the specification to correct informalities and minor editorial problems.

Reference element 46A has been added to the specification as "conduit system 46A" in paragraph 32.

Reference elements 152A and 152B have been added to the specification as "valves 152A, 152B" in paragraphs 44-45, 48, and 57.

Reference element 162 has been added to the specification as "choke 162" in paragraph 54.

Reference element 170 has been removed from Figure 2, on the submitted Replacement Sheet 2.

Reference element 172 has been added to the specification as "cap 172" in paragraph 50.

Withdrawal of the objection is respectfully requested by the Applicant.

Claims 1-17 and 19-55 remain pending in the application upon entry of this Response. Claim 18 has been cancelled without prejudice by the Applicant. Claims 1-17 and 19-55 stand rejected by the Examiner. Reconsideration of the rejected claims is requested for reasons presented below.

Claims 23-26 and 44-49 stand rejected under 35 U.S.C. § 102(e) as being anticipated by *Aaltonen et al.*, U.S. Pub. No. 2003-0165615, herein *Aaltonen*. The Examiner asserts that *Aaltonen* discloses all of the claimed elements. The Applicant respectfully traverses the rejection.

Claim 23 has been amended to depend from claim 19, which does not stand rejected under 102(e) as being anticipated by *Aaltonen*. Claims 24-26 depend from claim 23. Therefore, the rejection of claims 23-26 should be overcome due to the narrower scope of these claims relative to claim 19.

The Examiner states that *Aaltonen* discloses "ruthenium-containing having at least one open chain dienyl ligand (paragraph 0054)." The Applicant respectfully disagrees. *Aaltonen* discloses several ruthenium precursors that are cyclopentadienyl compounds and beta-diketonate compounds, but the Applicant finds no disclosure in paragraph 54, or anywhere in *Aaltonen*, of a ruthenium-containing compound having at least one open chain dienyl ligand.

Also, the Examiner states that *Aaltonen* "discloses forming the ruthenium on a low-k material (paragraphs 0063 and 0064)." Again, the Applicant respectfully disagrees. *Aaltonen* discloses that the barrier layer 52 "is deposited **over the substrate**," and the ruthenium "is grown by ALD **on the substrate**." (**emphasis added** – paragraphs 63-64). *Aaltonen* remains silent to forming the ruthenium on a low-k material.

Therefore, *Aaltonen* does not teach, show, or suggest a method for forming a ruthenium material on a substrate, comprising depositing a barrier layer on a substrate during a first ALD process, wherein the barrier layer comprises a material selected from the group consisting of tantalum, tantalum nitride, tantalum silicon nitride, titanium, titanium nitride, titanium silicon nitride, tungsten, tungsten nitride, and combinations thereof, and exposing the substrate sequentially to a ruthenium-containing compound and a reducing gas to form a ruthenium layer on the barrier layer during a second ALD

process, wherein the ruthenium-containing compound is selected from the group consisting of bis(dialkylpentadienyl)ruthenium compounds, bis(alkylpentadienyl)ruthenium compounds, bis(pentadienyl)ruthenium compounds, and combinations thereof, as recited in claim 19, and claims 23-26 dependent thereon.

Also, *Aaltonen* does not teach, show, or suggest a method for forming a ruthenium layer on a low-k material, comprising positioning a substrate containing the low-k material within a process chamber, maintaining the substrate at a temperature within a range from about 200°C to about 400°C, exposing the low-k material to a ruthenium-containing compound comprising ruthenium and at least one open chain dienyl ligand, forming a ruthenium-containing compound film on the low-k material, purging the process chamber with a purge gas, reducing the ruthenium-containing compound film with a reductant comprising an oxygen-containing gas, and purging the process chamber with the purge gas, as recited in claim 44, and claims 45-49 dependent thereon.

Withdrawal of the rejection is respectfully requested by the Applicant.

Claims 1-17, 19-22, 27-43, and 50-55 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Aaltonen* in view of *Kim*, U.S. Pub. No. 2002-0173054, herein *Kim*. The Examiner asserts that it would have been obvious for one skilled in the art to modify *Aaltonen* to include the claimed ruthenium precursor compounds such as C1-C8 alkylcyclopentadienyl compounds as taught by *Kim* in order to remove the reaction products. The Applicant respectfully traverses the rejection.

The Examiner has not presented a motivation to combine *Aaltonen* and *Kim*. The Examiner states that it is obvious to modify *Aaltonen* to include the claimed ruthenium precursor compounds such as C1-C8 alkylcyclopentadienyl compounds as taught by *Kim*. However, *Aaltonen* already discloses a C1-C8 alkylcyclopentadienyl compound, namely bis(pentamethylcyclopentadienyl)ruthenium. (paragraph [0054]). Conversely, *Kim* never discloses a particular C1-C8 alkylcyclopentadienyl compound, just the broad genus of compounds amongst a huge list of other generically recited genres of compounds. The Applicant asserts that there is absolutely no motivation to modify *Aaltonen* that already discloses the use of a C1-C8 alkylcyclopentadienyl

ruthenium compound in order to include ruthenium precursor compounds such as C1-C8 alkylcyclopentadienyl compounds as taught by *Kim*.

Kim discloses a process for fabricating a ruthenium film by using an ALD technique. *Kim* discloses ruthenium precursors having the chemical formula RuX_2 or RuX_3 where "X is a material selected from the group consisting of H, C₁~C₁₀ alkyl, C₂~C₁₀ alkenyl, C₁~C₈ alkoxy, C₆~C₁₂ aryl, β -diketonates, cyclopentadienyl, C₁~C₈ alkylcyclopentadienyl and derivatives thereof including halogens." (paragraph [0020]). As stated above, *Aaltonen* discloses several ruthenium precursors that are cyclopentadienyl compounds and beta-diketonate compounds. Both *Aaltonen* and *Kim* remain completely silent to a ruthenium-containing compound having at least one open chain dienyl ligand, dialkylpentadienyl ligands, or the other claimed ruthenium precursors.

Aaltonen and *Kim* disclose cyclopentadienyl ruthenium compounds (e.g., ruthenocene compounds) that the present application teaches away from. The present application teaches that ALD processes which use cyclopentadienyl ruthenium compounds generally "deposit ruthenium layers having an increased electrical resistance," require "a high absorption temperature above 400°C" that "may damage device structure within a sensitive low-k dielectric environment," and the deposited ruthenium layers often "fail tape testing due to the low adhesion of the underlying layer." (paragraph [0063] of the present application). The present application distinguishes the cyclopentadienyl ruthenium compounds of *Aaltonen* and *Kim* by utilizing open chain dienyl ruthenium compounds. Experiments in the specification provide a comparison between the claimed ruthenium-containing compound (Precursor A, which is bis(2,4-dimethylpentadienyl) ruthenium), with that of a ruthenocene compound (Precursor B, which is bis(ethylcyclopentadienyl) ruthenium. (See paragraphs [0099]-[0101] and Table 1).

Therefore, *Aaltonen* and *Kim*, alone or in combination, do not teach, show, or suggest a method for forming a film on a substrate surface, comprising positioning a substrate within a process chamber, exposing a ruthenium-containing compound to the substrate, wherein the ruthenium-containing compound is selected from the group consisting of bis(dialkylpentadienyl)ruthenium compounds,

bis(alkylpentadienyl)ruthenium compounds, bis(pentadienyl)ruthenium compounds, and combinations thereof, purging the process chamber with a purge gas, reducing the ruthenium-containing compound with a reductant to form a ruthenium layer on the substrate, and purging the process chamber with the purge gas, as recited in claim 1, and claims 2-10 dependent thereon.

Also, *Aaltonen* and *Kim*, alone or in combination, do not teach, show, or suggest a method for forming a layer comprising ruthenium on a substrate surface within a process chamber, sequentially comprising a) exposing a substrate to bis(2,4-dimethylpentadienyl)ruthenium to form a ruthenium-containing layer on the substrate, b) purging the process chamber with a purge gas, c) reacting a reducing gas with the ruthenium-containing layer, and d) purging the process chamber with the purge gas, as recited in claim 11, and claims 12-17 dependent thereon.

Also, *Aaltonen* and *Kim*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium material on a substrate, comprising depositing a barrier layer on a substrate during a first ALD process, wherein the barrier layer comprises a material selected from the group consisting of tantalum, tantalum nitride, tantalum silicon nitride, titanium, titanium nitride, titanium silicon nitride, tungsten, tungsten nitride, and combinations thereof, and exposing the substrate sequentially to a ruthenium-containing compound and a reducing gas to form a ruthenium layer on the barrier layer during a second ALD process, wherein the ruthenium-containing compound is selected from the group consisting of bis(dialkylpentadienyl)ruthenium compounds, bis(alkylpentadienyl)ruthenium compounds, bis(pentadienyl)ruthenium compounds, and combinations thereof, as recited in claim 19, and claims 20-26 dependent thereon.

Also, *Aaltonen* and *Kim*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium film on a dielectric material on a substrate, comprising positioning the substrate within a process chamber, exposing a ruthenium-containing compound to the dielectric material, wherein the ruthenium-containing compound is selected from the group consisting of bis(dialkylpentadienyl)ruthenium compounds, bis(alkylpentadienyl)ruthenium compounds, bis(pentadienyl)ruthenium compounds, and combinations thereof, purging the process chamber with a purge gas, reducing the

ruthenium-containing compound with a reductant to form the ruthenium layer on the dielectric material, and purging the process chamber with the purge gas, as recited in claim 27, and claims 28-35 dependent thereon.

Also, *Aaltonen* and *Kim*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium layer on a substrate surface, comprising positioning a substrate within a process chamber, exposing the substrate to a ruthenium-containing compound comprising ruthenium and at least one open chain dienyl ligand, forming a ruthenium-containing compound film on the substrate, purging the process chamber with a purge gas, reducing the ruthenium-containing compound film with a reductant comprising at least one reagent selected from the group consisting of oxygen, nitrous oxide, nitric oxide, nitrogen dioxide, and combinations thereof, and purging the process chamber with the purge gas, as recited in claim 36, and claims 37-43 dependent thereon.

Also, *Aaltonen* and *Kim*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium layer on a low-k material, comprising positioning a substrate containing the low-k material within a process chamber, maintaining the substrate at a temperature within a range from about 200°C to about 400°C, exposing the low-k material to a ruthenium-containing compound comprising ruthenium and at least one open chain dienyl ligand, forming a ruthenium-containing compound film on the low-k material, purging the process chamber with a purge gas, reducing the ruthenium-containing compound film with a reductant comprising an oxygen-containing gas, and purging the process chamber with the purge gas, as recited in claim 44, and claims 45-53 dependent thereon.

Also, *Aaltonen* and *Kim*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium-containing layer on a low-k material, comprising positioning a substrate containing the low-k material within a process chamber, maintaining the substrate at a temperature within a range from about 200°C to about 400°C, exposing the low-k material to bis(2,4-dimethylpentadienyl)ruthenium to form a ruthenium-containing compound film, purging the process chamber with a purge gas, reducing the ruthenium-containing compound film with a gas comprising oxygen, and purging the process chamber with the purge gas, as recited in independent claim 54.

Also, *Aaltonen* and *Kim*, alone or in combination, do not teach, show, or suggest a method for forming a ruthenium-containing layer on a copper-barrier material, comprising positioning a substrate containing a tantalum-containing material within a process chamber, maintaining the substrate at a temperature within a range from about 200°C to about 400°C, exposing the tantalum-containing material to bis(2,4-dimethylpentadienyl)ruthenium to form a ruthenium-containing compound film, purging the process chamber with a purge gas, reducing the ruthenium-containing compound film with a gas comprising oxygen, and purging the process chamber with the purge gas, as recited in independent claim 55.

Withdrawal of the rejection is respectfully requested by the Applicant.

Claims 1-4, 11, 27-30, and 36-40 stand provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-2 and 27-29 of co-pending U.S. Ser. No. 10/634,662.

Also, claims 9-10, 16-18, 35, 44, 48, and 54-55 stand provisionally rejected on the ground of nonstatutory obviousness-type double patenting as being unpatentable over claims 1, 2 and 27-29 of co-pending U.S. Ser. No. 10/634,662 in view of *Aaltonen*.


A terminal disclaimer compliant with 37 C.F.R. 1.321(c) is attached along with this Response. Accordingly, the Applicant respectfully requests withdrawal of these rejections.

In conclusion, the references cited by the Examiner, alone or in combination, do not teach, show, or suggest the claimed invention.

The secondary reference made of record, *DelaRosa et al.*, U.S. Pat. No. 6,527,855, is noted. However, it is believed that the secondary reference is no more pertinent to the Applicant's disclosure than the primary references cited in the Office Action. Therefore, the Applicant believes that a detailed discussion of the secondary references is not necessary for a full and complete response to this Office Action.

Having addressed all issues set out in the Office Action, the Applicant respectfully submits that the claims are in condition for allowance and respectfully request that the claims be allowed.

Respectfully submitted,



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